

# Studies for Pixel Module Alignment with Overlap Residuals

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Acknowledgments: Thanks to Max, Tobi, Beate and Thijs for their ntuples and useful discussions.

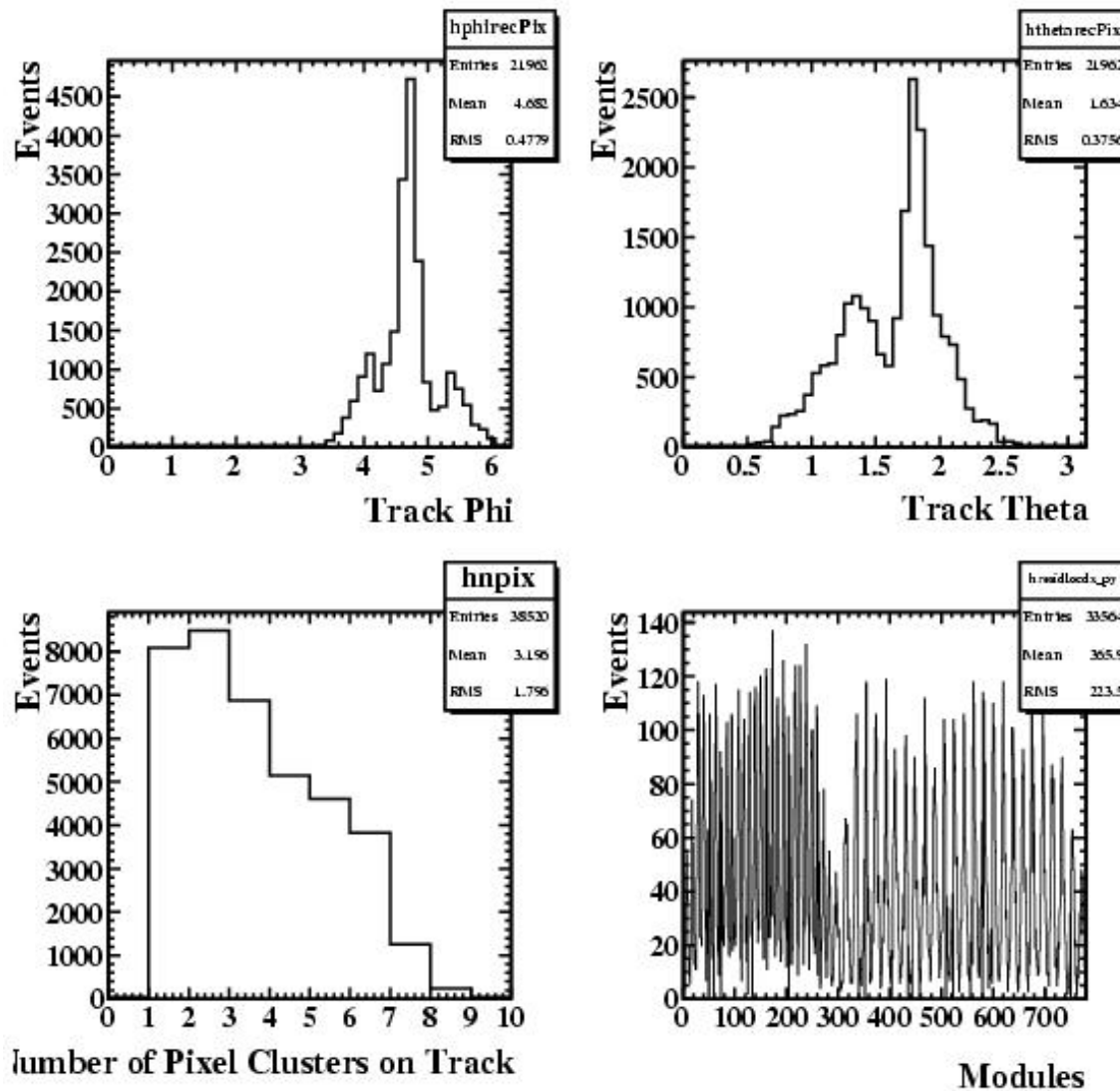


# Introduction

- Impressive progresses have made recently in terms of understanding pixel barrel alignment.
- There are significant fraction of cosmic tracks passing through adjacent modules as Tobi showed, which could be used to stitch module together, similar to what we did for endcapA cosmic test in SR1.
- Unfortunately, it requires lots of cosmic to completely coverage of a layer or disk, so at the end, there are only 6 or  $6 \times 13$  degrees of freedom remaining.
- The current statistics at least provide some cross checks.
- Focus on most of no bfield cosmic data (52425 Pixel tracks in runs 88463 - 92057).
- Default cosmic tracking with Pixel geometry Survey + GX2L1L2.



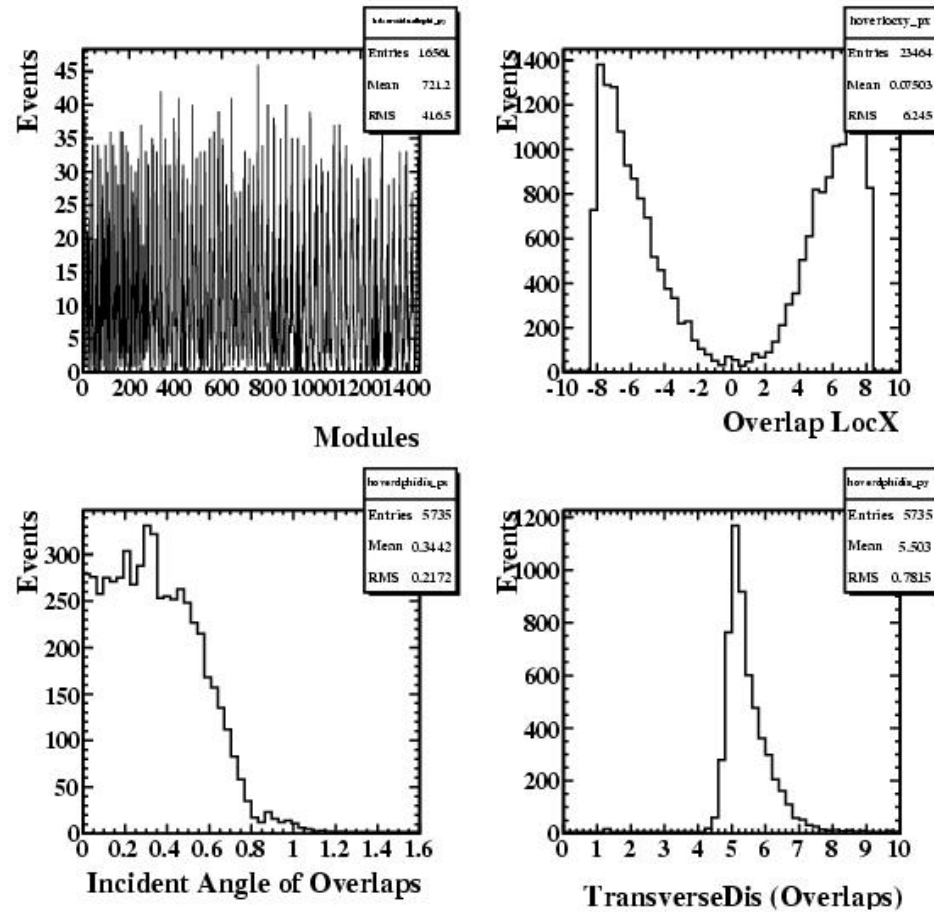
# Pixel Track Distributions



- Note: the bottom right shows hits per module in first two layers.



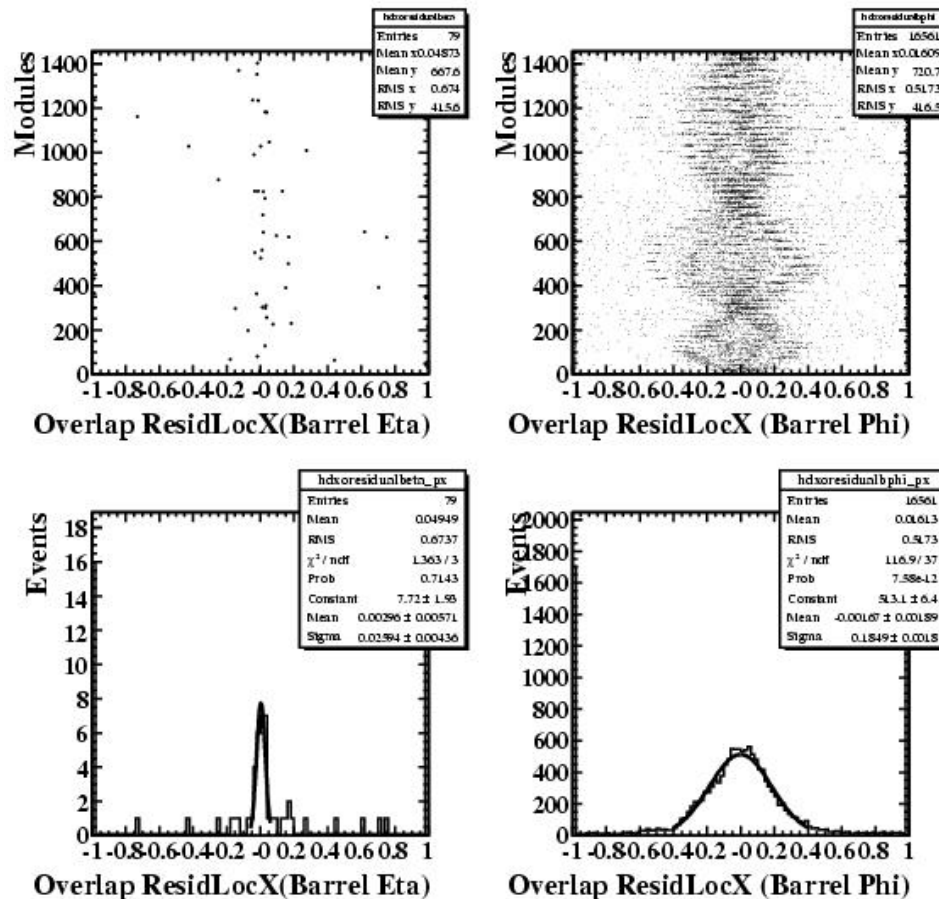
# Overlaps in Pixel Barrel



- Selecting overlap hits in pixel barrel, separating, in eta and phi directions
- The transverse distance peaking at 5 mm, comparing to 4.25 mm in the endcap.



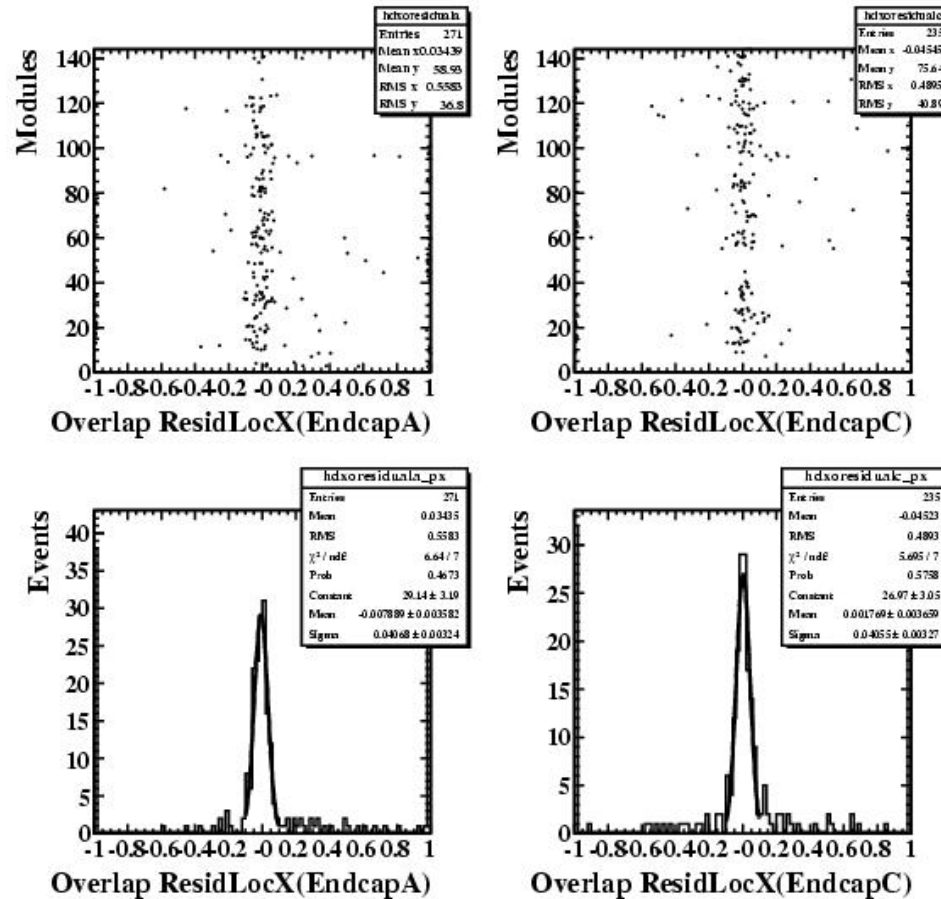
# Overlap Residuals in Pixel Barrel



- Selecting overlap hits in the same stave  $\delta\eta = 1$  or different stave  $\delta\phi = 1$
- The overlap residuals is  $26 \mu\text{m}$  in the same stave while the residuals between staves seems bow significantly in the middle of barrel.



# Overlap Residuals in Pixel Endcaps



- The overlap residuals in endcaps are about  $40 \mu m$  or  $28 \mu m$  for resolution.
- Not far from  $21 \mu m$  from SR1 cosmic test.



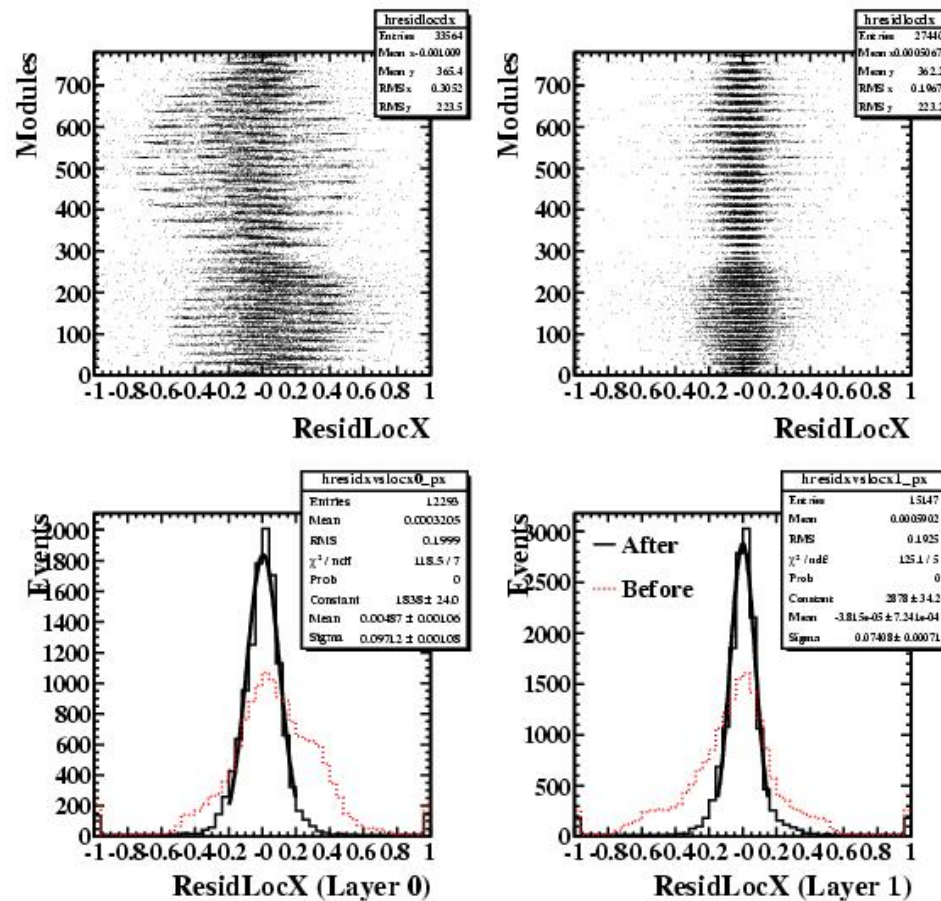
# Analysis Strategies

- Ideally, we could close one layer using overlap residuals and align the rest of layers respect to it.
- For now, we will fix layer 2 and try to align the layer 0 and 1 to it and check to see if the overlap residual improves or not
- Selecting 3 or more good pixel clusters with  $\text{tot} > 10$  and  $\text{groupsize} < 5$ .
- Two far clusters are on layer 2
- Fixing the layer 2 geometry with initial alignment (Survey + GX2L1L2)
- Fit a line with two far hits and compute the residuals for hits on layer 0 and 1
- Assuming the module as a rigid body with at least 30 hits, we can minimize the residuals to obtain the relative alignment in terms of three transformations ( $T_x$ ,  $T_y$ ,  $T_z$ ) and three rotations ( $\alpha$ ,  $\beta$ , and  $\gamma$ ).





# Residuals in LocX Before and After Corrections

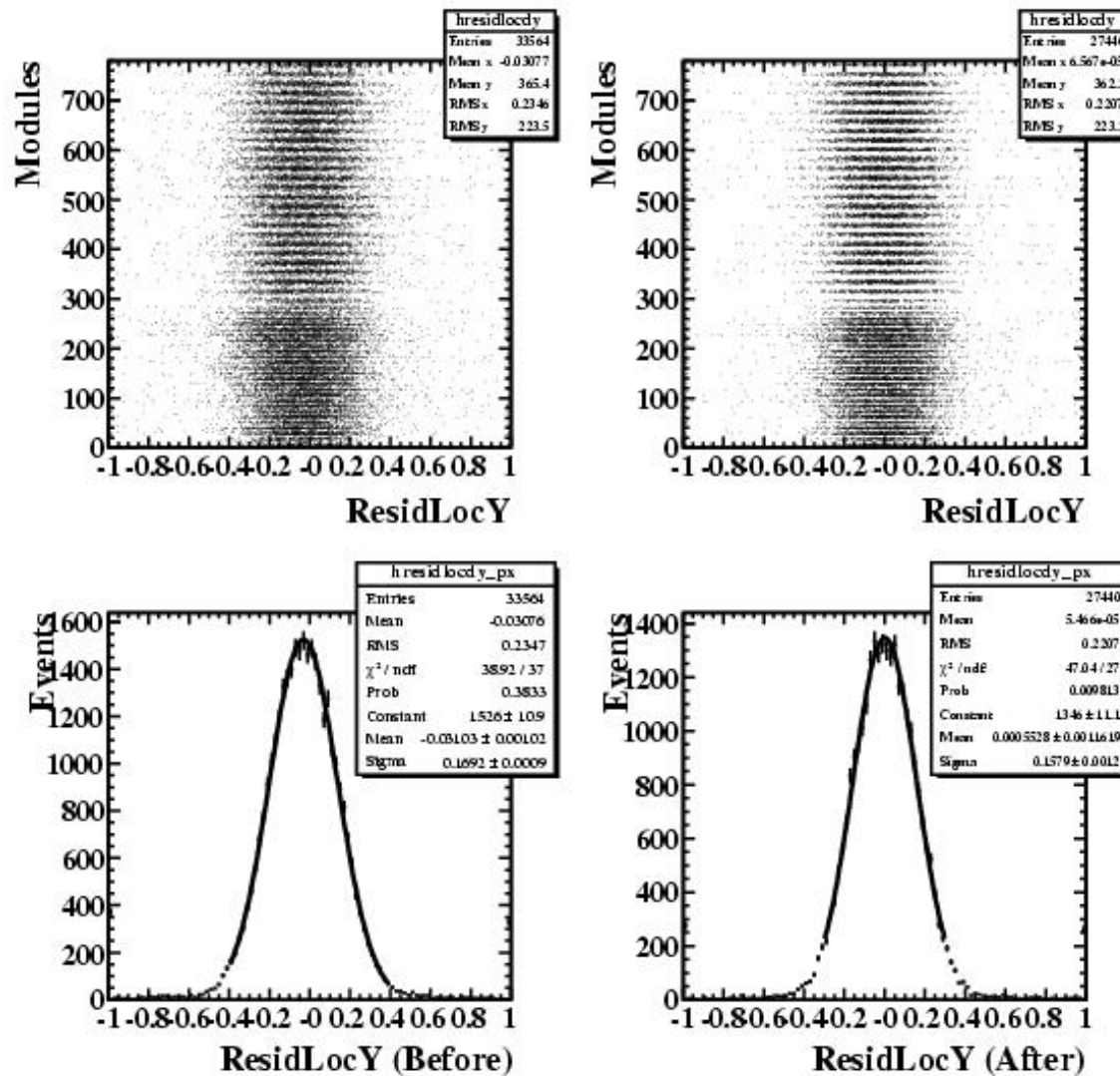


- The residual of Layer 0 and 1 improves to 97 and 74  $\mu\text{m}$  after correction
- Some of differences are due to layer 2 misalignment





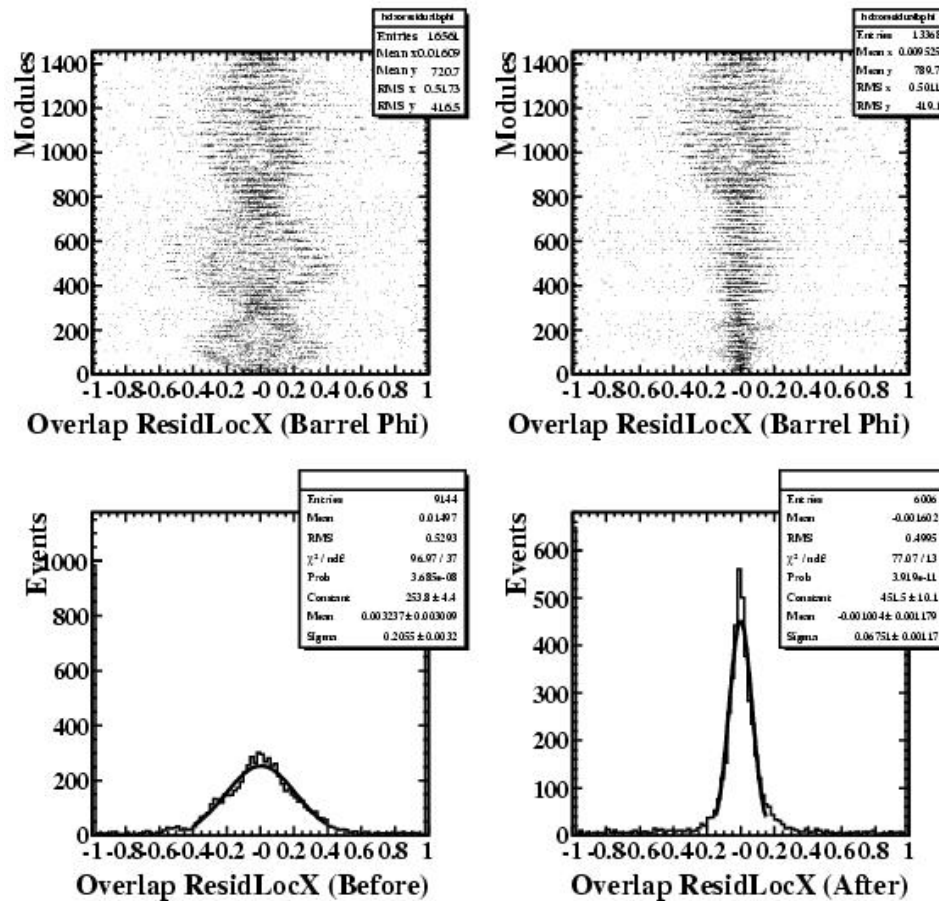
# Residuals in LocY Before and After Corrections



- There is no significant improvement in residual LocY with the corrections.



# Cross Checks with Overlap Residuals



- The overlap residuals seems significant improved from 205.5 to 67.5  $\mu m$  after corrections
- The corresponding resolution is about 48  $\mu m$ , still far from the expected resolution from MC.



## ToDo List and Conclusions

- The cosmic tracks provides significant fraction of overlaps between adjacent modules, which are most valuable for understanding the pixel alignment.
- Trying to include more cosmics with bfield to get more overlaps.
- This would provide a nice way to align the pixel detector internally.
- There may not enough cosmics to cover whole barrel, but obtaining alignment for most barrel modules would be possible before the beam data.

